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author: L. K. Schwab and R. W. Drisko, PhD

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CONTENTS

INTRODUCTION

Many Navy antenna towers are located in remote locations where maintenance facilities are limited and severe environment, such as marine or tropical exposure, causes rapid, localized, coating damage. The heights and configurations of these towers permit only steeplejacks or repairmen utilizing an aerial-serving platform to reach all areas. Even then, some areas are frequently hard to reach. Repair of damaged coatings by conventional means (e.g., sandblasting and spray painting) is very costly and, in some cases, impossible because of physical limitations or environmental regulations. Dry abrasive blasting, for example, is frequently restricted because of particulate emission. Thus, the Civil Engineering Laboratory (CEL) was directed by the Naval Facilities Engineering Command to develop optimum methods for in-place repair of damaged exterior antenna coatings.

Reference 1 describes initial laboratory and field studies on antenna coating repair materials and methods. This technical note is the second and final document of the investigation, which included: (1) accelerated, salt-spray testing of experimental and specification coating systems; (2) results of 3 years of field testing of candidate materials from accelerated tests on an antenna positioner at the Pacific Missile Test Center (PMTC), Point Mugu, Calif.; (3) development of cleaning and coating techniques and equipment; (4) testing of developed coating systems and cleaning and coating techniques and equipment on two vortex towers in a very corrosive environment at PMTC; and (5) a summary of currently recommended practices for protecting antenna towers from a corrosive environment.

BRIEF DISCUSSION OF FIELD TEST ON ANTENNA POSITIONER AT PMTC

Reference 1 provides detailed information on the application and initial ratings of 32 coating systems (all consist of one coat of primer and one coat of topcoat) on an antenna positioner located at the lagoon area at PMTC. Monthly ratings were made for a total of 3 years, at the end of which, 19 of the 32 systems were providing good protection to the steel. As far as is possible, ASTM photographic standards were used to rate these specimens. Table 1 lists coating conditions after years of exposure.

Ratings at the end of 3 years for various properties generally ranged from a high of 10 (perfect) to a low of 0. Heavy chalking, common to all exterior epoxies, occurred with all the experimental coating systems. However, this condition does not result in loss of

protection unless it leads to coating erosion. Some discoloration, such as yellowing or rust streaking, was evident on all systems. Systems 38 and 39 (nearest the ground) had the most discoloration; systems 16 and 23 (positioned in a more protected area) had the least. Rusting, ASTM Type I (pinpoint), was found on 13 of the 32 systems. Showing the most rusting were systems 38 and 39; while systems 11, 14, 17, 20, 21, 34, 35, 36, 37, 40, and 41 were slightly better. Systems 17, 20, and 21 exhibited peeling, and systems 11, 14, 17, and 20 exhibited cracking. Wrinkling shows on systems 34 through 41. No blistering was observed on any of the coating systems.

LABORATORY SALT-SPRAY EXPOSURE OF COATING SYSTEMS

Laboratory salt-spray testing (Method 6061 of Ref 2) is often used as a relatively quick procedure for screening coatings for ability to protect steel from corrosion. In such testing, coated panels are exposed in an enclosed chamber in an atmosphere of 5% or 20% salt spray at a temperature of approximately 95°F.

The results of salt-spray exposure of systems 42 through 53 were reported in Reference 1. Systems that provided above-average protection in Phase 1, plus 25 additional coating systems, are discussed in this section of this document. This group of coatings, then, form the basis for selection of those coatings that could be used for field exposure on vortex towers at PMTC.

First Series

Panel Preparation. Prerusted 6x12-inch steel panels were cleaned manually — first by wire-brushing and then by scrubbing in water with a medium-hard bristle brush. The panels were then dipped in methyl ethyl ketone (MEK) to remove water and allowed to dry. No desiccator large enough to hold these panels was available, so they were placed overnight in a slightly warm dry oven to prevent corrosion before use. One-half of the cooled panels received a special surface treatment before coating (see Table 2). This surface treatment consisted of brushing with the same metal conditioner and rust converter used with systems 43, 45, and 47 in the initial study (Ref 1). All coatings were primed, using a 1-inch-wide brush. One-half of each set of treated and untreated panels were machine-scribed to bare metal with an "X." This first series used MIL-P-24441 (Formula 150) epoxy-polyamide primer and MIL-P-24441 (Formula 152) epoxy-polyamide topcoat as the coating system standard. Systems 10, 12, 13, 15, 16, 18, 19, 21, 34, 35, 36, 38, 40, and 41 (Ref 1) were tested. The coated panels were placed in a 5% salt-spray cabinet and rated periodically by the same rating system used in Reference 3.

Results. The panels were left in the salt spray for 154 days (Table 3). At the end of this period all the scribed panels had discolored from rusting and tuberculation in scribed areas. All systems

showed some blistering around the scribed areas, but systems 12, 18, 35, and 38 also had blistering elsewhere. Except for systems 21 and 38, all systems had slight undercutting. All systems, except systems 18 and 30, would probably provide several years of protection to steel under normal exterior exposure.

Second Series

Panel Preparation. Shop personnel cleaned the prerusted experimental panels by power grinding. The panels were then scrubbed in water with a bristle brush, dipped in MEK, and allowed to dry. All coatings were applied by spraying, using the experimental backpack applicator.* Systems 54, 55, 57, 58, 59, 60, 66, 67, 68, 69, and 70 comprised this series. The types and sources of the coating systems can be found in Appendix A.

Results. The salt-spray conditions and inspections were similar to those of the first series. All systems were exposed to salt spray for 123 days, except systems 55, 57, 67, and 70, which were exposed for only 98 days.** After 123 days, systems 69 and 70 had failed because of delamination of the topcoat from the primer. System 67 performed the best (see Table 4) showing only slight overall blistering and blistering scribe. Second best was system 57, which showed discoloration and rusting, Type I. All the other systems showed discoloration, tuberculation, and rusting scribes. Systems 55, 67, 68, and 69 showed slight blistering, and systems 54, 58, 59, 60, 66, and 68 showed undercutting.

CLEANING AND COATING APPLICATION EQUIPMENT

Three of the most common causes for coating failure on steel towers are: (1) inadequate surface preparation, (2) improper application of the coating, and (3) incompatibility of the new and previous coatings. To reduce coating failures due to (1) or (2) surface preparation and coating application equipment was investigated. As a result of the investigation, special equipment was designed and used in preparation of both the second series laboratory tests and the field tests.

Design

This special equipment, shown in Figure 1, was designed for mounting on a backpack for a painter to carry it to areas to be coated. The backpack was designed and fabricated by Advanced Coatings and Chemicals, South El Monte, Calif., under a contract awarded by CEL. Three criteria were uppermost in its design: light weight, portability, and sufficient

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*See section on CLEANING AND COATING APPLICATION EQUIPMENT.

**The 25-day difference in exposure time of some of the panels was due to relocating the salt-spray cabinet. After relocating the cabinet, additional panels were added to the test.

power for operation. All components of the system were off-the-shelf items. On a typical backpack harness was mounted a 17x8x1/4-inch aluminum plate to which a Binks Oil-Less Air Compressor Model 34-1051 was attached. This compressor, powered by a 3/4-hp, 1,725-rpm electric motor, produced a maximum pressure of 50 psi. Surface preparation tools included a Chicago Monarch Model 25 chipping hammer/needle gun (Figures 1(b) and (c)) and a Black and Decker 16,000-rpm, air-operated disc sander (Figure 1(d)). The paint gun was a Binks Model 62 with a Binks Model 80 1-quart pot (Figure 1(e)). Six-foot long feedlines extended from the compressor to the pot and from the pot to the gun. The complete system weighed approximately 67 pounds. In the field, tower electrical outlets or extension cords to other outlets were to provide power for operation.

Results

The backpack surface preparation and paint application equipment was satisfactorily used in the laboratory to clean and coat the experimental panels. When the equipment was used for surface preparation and coating application on the antenna towers at PMTC, however, the following problems were noted: (1) the system was too heavy to use for an extended period of time; (2) electric power was not available so air pressure had to be obtained from a portable compressor; and (3) the compressor produced inadequate pressure for satisfactory cleaning with the tools. A larger portable compressor had to be used to provide the necessary pressure.

If such alternative equipment were chosen for future use, a diesel-driven air compressor could be used for both cleaning and application. A clamped, rigid line could run from the compressor at the base to the top of the antenna. Quick disconnects for attachment of a flexible pneumatic hose could be located at intervals of 20 feet. This hose could be fitted to a reel mounted on the backpack harness in place of the compressor and motor. While such an alternative system was not tested on the vortex towers, it is believed that all problems encountered with the original backpack system would be eliminated by use of such an system. For instance, a pressure hose was lifted in similar fashion with a cherry picker.

FIELD EXPOSURE OF COATINGS ON VORTEX TOWERS AT PMTC

Preparation of Test Areas

Portions of two steel vortex towers located on a beach at the western perimeter of PMTC were used as substrates for the second field exposure of antenna coating repair. These towers were erected in 1954 and have been painted three times since then. The towers are exposed to periodic wind-blown sand and salt spray from the ocean, with the lower 20 feet subject to sand abrasion at times of high wind. Large areas of the legs and chord braces had extensive coating loss and rusting. Most connectors had significant galvanic corrosion.

For the coating tests, all corrosion, loose coating, and dirt were removed from the 10- and 20-foot elevation test areas on each tower before application of the coatings. A pneumatic chipping hammer removed the larger areas of corrosion and loose coating; this preparation was followed by use of a grinder equipped first with coarse-grit (aluminum oxide #36) and then fine-grit (aluminum oxide #60) disks. The connectors and areas surrounding them were cleaned with a needle gun.

Two experimental coating systems were applied to each of the chord braces and their leg connectors at the 10- and 20-foot levels of each tower. Appendix B lists the formulations of the experimental coatings. The experimental backpack application equipment was used to apply systems 58, 59, and 60. All other systems were applied with a 2-inch wide brush. Appendix C lists the formulas of each two-coat system used on the towers, the material sources, and the total dry film thicknesses. In accordance with Civil Aeronautics Board Regulations, the different levels of the antennas were alternately painted red and white. Random locations on the test areas were assigned to these systems.

Coating Selection

The selection of the coating systems for exposure on the vortex towers was two-fold. First, new titanate coupling agents came to the attention of CEL personnel. Coatings containing titanate agents were formulated and exposed in a laboratory salt-spray chamber in accelerated tests discussed earlier in this document. Some of these coatings were selected for long-term exposure on the vortex towers. Second, other coatings selected had proved themselves in applications other than on antenna towers, and it was decided to determine their usefulness as coatings under tower exposure conditions.

The coating used for the standard for this exposure test was MIL-P-24441 epoxy-polyamide (150 for the primer and 156 for the topcoat).

Results

Inspection and rating of the experimental coatings were made monthly, using the ASTM rating system described previously. Exposure ratings after 15 months are shown in Table 5. At this time the coatings located at the 20-foot elevation on the tower nearest the ocean had somewhat greater deterioration than the other. A brief summary of significant effects on the exposed coatings is listed as follows:

Effect	Systems
Chalking	All, except 63
Discoloration	54, 56, 58, 59, 63
Cracking	58, 62
Slight peeling	56
Rusting, Type I	54, 56, 57, 58, 59
Rusting, Type II	56, 58

The overall general protection was very good for systems 55, 57, and 60 through 65 of the 12 systems.

PRACTICES RECOMMENDED BY CEL FOR PROTECTING ANTENNA TOWERS*

Antenna towers and supporting communication equipment are widely scattered throughout the world. Many are at remote locations that have very corrosive environments (Figures 2 and 3) and very limited maintenance services available. Thus, the greatest care must be taken in siting, designing for corrosion control, and planning maintenance if vital communication systems are to be kept operable.

Types of Antennas

Most antenna towers and supporting equipment are constructed of (1) steel, which corrodes readily (Figure 4); (2) galvanized steel (Figure 5), which can provide several years of protection before requiring a coating; (3) or aluminum, which can provide many years of service uncoated but is usually coated in a severe environment. Circularly disposed (Wullenweber) antenna arrays are unique in that wood is used in much of their structural supports (Figure 6). Treated wood is generally used to prevent termite attack. All towers should be coated to provide visibility to aircraft unless acceptable warning lights are used.

Design for Corrosion Control

Faulty design is often a major factor leading to the corrosion of structures and equipment exposed to exterior weathering (Ref 4). Location, structural features, and joining require special consideration in towers and communication equipment construction.

Facilities should be located as far as possible from the sea and from winds carrying salt spray. It has been noted that towers located several miles from an ocean have their greatest degree of corrosion at 150- to 200-foot elevations where concentrations of sea salt carried by winds are greatest. Sand borne by winds may cause erosion of coatings or metal on towers. Similarly, towers should not be located downwind from sources of corrosive industrial pollution.

Box, rectangular, and tubular beams are much less susceptible to corrosion than tees, channels, and I-beams because the latter permit greater accumulations of salt, moisture, and other contaminants that accelerate corrosion or are more difficult to clean and coat. It is good practice to smooth all welds, edges, and other rough surfaces before coating to permit easier, more uniform coating application. Stairs, railings, ladders, and support trailers present irregular or inaccessible surfaces difficult to coat (Figures 7 and 8).

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*Based on a paper presented at USAF High Work Safety Conference at Norton Air Force Base, December 5-7, 1978.

Crevices may accelerate corrosion and are difficult to coat. Continuous welding is more costly than skip welding, but it eliminates such crevices. Riveted and bolted connections can also produce crevices. Insulation not only minimizes crevices but may also eliminate galvanic corrosion associated with contact of dissimilar metals.

Guy lines should be placed so they do not contact each other (Figure 9) or structural members during high winds. The use of protective sleeves to prevent abrasion damage by such action is not an acceptable method of preventing contact (Figure 10).

Surface Preparation for Coating Repair

Antenna towers and supporting equipment are best coated in a steel fabrication shop and then touched up later in the field, as necessary. Because of the difficulty and cost of coating assembled antenna towers, it is best to obtain as high a level of surface preparation and as good a coating as possible to start with to forestall future maintenance as long as possible. Abrasive blasting, as with almost all steel structures, is the preferred method of cleaning steel towers for coating, either before or after erection, because it produces a good surface texture for bonding (Ref 5). The different levels of surface preparation commonly used for new steel tower construction are given in Table 6.

The level of surface preparation desired depends upon (1) the type of coating to be used, (2) the severity of the environment, and (3) the length of protection desired. Exterior abrasive blasting is being restricted in some locations because of air pollution caused by particulates emitted into the atmosphere. Thus, greater use may have to be made of different methods of mechanical cleaning (Figures 1(b), (c), (d)). The Tri-Services Painting Manual (Ref 6) describes such cleaning methods as sand and power tools (brushes, grinders, sanders, hammers, chisels, and scalers) and flame and chemical cleaning. Reference 7, published by the Steel Structures Painting Council (SSPC), has standards for hand-tool cleaning (SSPC-SP No. 2) and for power-tool cleaning (SSPC-SP No. 3). Flame and chemical cleaning are not usually practical on tower structures.

Galvanized steel and aluminum are solvent-cleaned, if new, and then hand-tool-cleaned or brush-off-blasted (SSPC-SP No. 4) before coating.

Coating Selection

Coating selection is based on the properties of the coating system; some of these are discussed below.

1. Unmodified drying oil coatings wet steel surfaces very well, but cure very slowly and lack toughness and durability for tower coatings.

2. Alkyds (modified drying oil coatings) wet steel surfaces well, have good curing and protective properties, and are also rather tolerant of incompletely prepared surfaces.

3. Two types of lacquer (vinyl and chlorinated rubber) form tough, durable films and are easily topcoated because solvent in the applied coating softens the existing coating.

4. Chlorinated rubber coatings cure rapidly so that they can be utilized effectively where unpredictable rains or fogs limit times of coating application and curing.

5. Epoxies form tough, protective finishes, but the surfaces chalk freely in sunlight.

6. The polyamide-cured epoxies are more tolerant of incomplete surface preparation than other epoxies.

7. The chemically cured urethanes also produce tough coatings.

8. Aliphatic urethanes have good weathering properties and, thus, are sometimes used over epoxy primers to improve the exterior weathering of the coating system.

9. Zinc-rich coatings can give long-term cathodic protection to steel.

10. Inorganic zinc-rich coatings have better abrasion resistance than the organic zinc-rich coatings, but the latter have better topcoating properties.

Coating selection is summarized in Table 7 and discussed in more detail in Reference 8. Coatings applied in three or more coats at dry film thicknesses of 6 mils or more will give optimum barrier protection if free of voids (holidays).

Galvanizing is like a zinc-rich coating in that it also protects steel from corrosion by cathodic protection. Zinc-rich coatings weather better in marine atmospheric environments and are more easily applied and topcoated in place (Ref 9) than galvanizing. Thus, a pretreatment (wash) primer is used for alkyd systems on galvanized steel. A zinc dust-zinc oxide pigmentation rather than a zinc chromate or red lead pigmentation is generally used in alkyds that are applied over pretreatment-primed galvanized steel (Ref 6). Specially formulated epoxies can also be used over galvanized steel. It is desirable to keep a galvanized or inorganic zinc coating as a permanent primer protected by a topcoat to avoid preparing the underlying steel for coating repairs.

If aluminum structures are to be coated, an appropriate pretreatment (wash) primer, a zinc chromate alkyd primer, and an alkyd topcoat can be used (Ref 6). Even greater protection will be received from a coating system of pretreatment primer, epoxy primer, and aliphatic urethane topcoat.

Coating Antenna Guy Lines

Galvanized steel wire ropes are usually used to guy antennas and other towers, although aluminum-coated wire may be more corrosion-resistant when proper precautions are taken (Ref 10). In a CEL study

(Ref 11), thin preservatives formulated to penetrate galvanized steel guy lines provide only temporary protection, especially if applied after weathering of the guy lines. A petrolatum paste which encapsulates the guy line to provide a protective barrier seems more practical. CEL and the Naval Radio Station (I), Cutler, Maine (Ref 12), developed equipment (Figure 11) for the remote cleaning and coating of large diameter (1 to 3-1/4 inches) guy lines with petrolatum paste. A nylon brush (Figure 12) was used for cleaning the line on the ascent (Figure 13) and coating on the descent. This equipment is still performing very satisfactorily at Cutler, Maine.

Fiberglass-reinforced epoxy rods (Figure 14) are frequently used on circularly disposed (Wullenweber) arrays (Figure 6) or other systems where high dielectric strength, high tensile strength, and low elongation are required. If their protective coating is lost by weathering and the glass fibers are exposed, a loss in strength can result. It is normally a better investment to replace than recoat such deteriorated rods. Also, the weakest component is the end connector (Ref 13); therefore, protective coatings are especially important in this area.

COST CONSIDERATIONS FOR NEW STEEL CONSTRUCTION

Although life cycle coating costs associated with steel antenna towers vary widely with antenna design, remoteness from populated areas, and severity of environment, some conclusions can be made of the cost effectiveness of different coating procedures on new construction. On existing structures, coating maintenance procedures are largely determined by the type and condition of existing coatings. Reference 7 provides much practical information on the repair of existing coatings.

Surface preparation and priming of steel tower components is best done in a fabrication shop under controlled conditions. This results in a better quality product and reduces costs, even if touchup of damaged coatings is required in the field before erection of the tower. In Table 8 surface preparation and primer costs in a fabrication shop are compared to those in the field*. Costs of surface preparation and priming are much higher after tower erection (at least double on high towers).

Initial costs may be deceiving. Table 9 lists available cost data for five coating systems appropriate for antenna towers. Although the alkyd system is the cheapest of the five, it will ordinarily provide the shortest protection in a severe environment. Table 10 lists typical costs and service lives of these five coating systems in an industrial environment. It can be seen that in such moderate or in severe environments, the alkyd system would be the least cost effective.

In selection of a coating system for new construction, ease and cost of coating maintenance should be of great importance. A zinc-rich system will usually be the most cost effective if the zinc-rich primer

*If permitted.

becomes permanent so that little bare steel is ever exposed. If significant areas of steel will require spot cleaning and recoating, an alkyd or epoxy-polyamide system that is relatively tolerant of incompletely cleaned steel have advantages. Vinyl and chlorinated rubber systems are more easily topcoated than other systems because they are lacquers. Obviously, all significant factors must be considered before an optimum coating and procedure can be chosen for steel antenna towers.

SUMMARY OF RESULTS AND RECOMMENDATION

Most of the experimental paints exposed on the antenna positioner at Point Mugu provided excellent protection for 2 years in a marine atmospheric environment. These results correlated well with those from accelerated laboratory (salt-spray) testing.

After 6 months of field exposure, eight out of nine experimental coatings containing a butyl titanate corrosion-inhibiting agent provided very good protection. The performances of these materials will be monitored periodically so that results can be used in field tests when the opportunity arises.

The backpack equipment seem too heavy and too underpowered to be practical for field use. Reducing the weight by design change or lighter materials appears infeasible. The use of an air compressor on the ground with hose lines connected to the backpack appears to be a feasible alternative for this equipment.

It is recommended that the coatings and cleaning methods developed in this investigation be field-tested on a full scale if the opportunity arises.

ACKNOWLEDGMENTS

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Table 1. Ratings of Coatings on Antenna Positioners After Three Years of Exposure at PMR, Calif.

Coating System	General Protection	Discoloration	Chalking	Alligatoring Checking Cracking	Scaling Flaking Peeling	Rusting Type I	Blistering	Remarks
10	10-	9+	2	10	10	10-	10	
11	8+	8	2	8	10-	8+	10	
12	10-	9+	2	10	10	10-	10	
13	10-	9+	2	10	10	10-	10	
14	8+	9	2	8	10	8+	10	
15	10-	9	2	10	10	10-	10	
16	9-	8	2	10	10	9-	10	
17	7-	7	2	8	7	7-	10	
18	9+	8-	2	10	10	9+	10	
19	9	8+	2	10	10	9	10	
20	7	7	2	7	7	7	10	
21	9+	9-	2	10	10	9+	10	
22	10	9+	2	10	10	10	10	
23	10	10	2	10	10	10	10	
24	10	10-	2	10	10	10	10	
25	10	9+	2	10	10	10	10	
26	10	9+	2	10	10	10	10	
27	10	9+	2	10	10	10	10	
28	10	9-	2	10	10	10	10	
29	10	9-	2	10	10	10	10	
30	10	8+	2	10	10	10	10	
31	10	8	2	10	10	10	10	
32	10	8+	2	10	10	10	10	
33	10	6+	2	10	10	10	10	
34	9-	8/8	2	10	10	9-	10	Wrinkling

continued

Table 1. Continued

Coating System	General Protection	Discoloration	Chalking	Alligatoring Checking Cracking	Scaling Flaking Peeling	Rusting Type I	Blistering	Remarks
35	7	7/7	2	10	10	7	10	Wrinkling
36	9-	7-/7	2	10	10	9-	10	Wrinkling
37	7	6/6	2	10	10	7	10	Wrinkling
38	8-	6/7	2	10	10	5	10	Wrinkling
39	5	3/7	2	10	10	5	10	Wrinkling
40	7	6/6	2	10	10	7	10	Wrinkling
41	7	6/6	2	10	10	7	10	Wrinkling

Table 2. Laboratory Salt-Spray Exposure

System No.	Primer	Topcoat	Surface Treatment[a]	Dry Film Thickness (mil)
First Series				
10	Epoxy, amine-cured	MIL-P-24441-152[b]	1	5-6
12	MIL-P-24441-150[b]	MIL-P-24441-152[b]	1	4-5
13	Epoxy, amine-cured	MIL-P-24441-152[b]	2	5-6
15	MIL-P-24441-150[b]	MIL-P-24441-152[b]	2	5-6
16	Epoxy, amine-cured	Epoxy, amine-cured	1	4-6
18	MIL-P-24441-150[b]	Epoxy, amine-cured	1	4-6
19	Epoxy, amine-cured	Epoxy, amine-cured	2	4-7
21	MIL-P-24441-150[b]	Epoxy, amine-cured	2	5-6
34	Zinc-zinc alloy in medium oil alkyd	MIL-P-24441-152[b]	1	3-5
35	Zinc-rich chlorinated rubber	Chlorinated rubber	1	4-7
36	Zinc-zinc alloy in medium oil alkyd	Epoxy, polyamide-cured	1	4-5
38	Zinc-rich chlorinated rubber	Chlorinated rubber	2	6
40	Zinc-zinc alloy in medium oil alkyd	MIL-P-24441-152[b]	2	5-6
41	Zinc-zinc alloy in medium oil alkyd	Epoxy, polyamide-cured	2	5-7

(continued)

Table 2. Continued

System No.	Primer	Topcoat	Surface Treatment[a]	Dry Film Thickness (mil)
Second Series				
54	Alkyd	TT-E-789 Class A	-	6.1
55	Zinc-rich chlorinated rubber	Epoxy-urethane	3	5.7
57	Zinc-rich chlorinated rubber	MIL-C-81773	3	2.0
58	Epoxy-urethane	MIL-C-81773	3	5.6
59	Epoxy-urethane	MIL-P-24441-152[b]	3	7.5
60	Epoxy-urethane	Epoxy urethane	3	6.5
66	MIL-P-24441-150[b]	Epoxy urethane	3	9.0
67	Zinc-rich chlorinated rubber	MIL-P-24441-151[b]	3	4.7
68	Zinc-rich chlorinated rubber	MIL-C-81773	3	3.9
69	Zinc-rich chlorinated rubber	Chlorinated rubber	3	6.3
70	Zinc-rich chlorinated rubber	Epoxy-urethane	3	6.3

[a] 1 = Hand wire-brushed
2 = Hand wire-brushed, treated with manganese phospholene no. 7
3 = Mechanical grinding

[b] MIL-P-24441 is epoxy-polyamide.

Table 3. Panel Ratings of First Series of Coating Systems After 5% Salt Spray Exposure

Exposure (days)	Rating for Following Properties – General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting Type I	Rusting Type II	Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	Remarks
System 10														
7	10	9^+	10	10	10	10	10	10	9^+	10	10	10	6.1	Rust stain from scribe and hole in top
35	10^-	9^+	10	10	10	10	10	10^-	9	10	10	8/M[a]		"
63	10^-	9^+	10	10	10	10	10	9	9^-	10	10	8/M		"
92	9^+	9^+	10	10	10	10^-	10	9^-	9^-	10	10	8/M		"
118	9^+	9^+	10	10	10	10^-	10	9^-	9^-	10	10^-	8/M		"
154	9^+	9	10	10	10	10^-	10	8^+	9^-	10	9^+	8/M		"
System 12														
7	10	9^+	10	10	10	10^-	10	10	9	10	10	10	4.5	Rust stains from scribe
35	10^-	9^+	10	10	10	10^-	10	10	9	10	10	10		Rust stain from scribe and hole in top
63	10^-	9^+	10	10	10	10^-	10	9	9	10	10	10		"
92	9^+	8^+	10	10	10	10^-	10	8	8	10	9^+	10		"
118	9^+	8^+	10	10	10	10^-	10	8	8	10	9	10		"
154	9^-	8^+	10	10	10	10^-	10	8^-	8^-	9/F	9	10/F[a]		"
System 13														
7	10	10^-	10	10	10	10	10	10	10^-	10	10	10	5.5	Rust stains from scribe and hole in top
35	10	9^+	10	10	10	10	10	10	9^+	10	10	10		"
63	10^-	9^+	10	10	10	10	10	10^-	9^+	10	10	10		"
92	10^-	9^+	10	10	10	10^-	10	9^+	9^+	10	10	9^+		"
118	9^+	9^+	10	10	10	10^-	10	9^-	9	10	10^-	9/M		"
154	9^+	9^+	10	10	10	10^-	10	9^-	9	10	9^+	6-8/H[a]		"

[a] F = few; M = medium; H = heavy.

(continued)

Table 3. Continued

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting		Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	
						Type I	Type II							
System 15														
7	10^-	9	10	10	10	10^-	10	10	9	10	10	10	5.8	Few pin point rust spots
35	10^-	9	10	10	10	10^-	10	10	9	10	10	10		Rust stains from scribe and hole in top
63	10^-	9	10	10	10	10^-	10	10^-	9	10	10	10		"
92	10^-	9	10	10	10	10^-	10	9^+	9	10	10^-	10^-		"
118	9^+	9	10	10	10	10^-	10	9^+	9	10	10^-	10^-		"
154	9^+	9	10	10	10	10^-	10	9	9^-	10	9^+	6/F		"
System 16														
7	10	10^-	10	10	10	10	10	10	10^-	10	10	10	5.0	Rust stain from scribe and hole in top
35	10	10^-	10	10	10	10	10	10	10	10	10	10		"
63	9^+	9^+	10	10	10	10	10	9	9	10	10	10		"
92	9^+	9^+	10	10	10	10^-	10	9^+	9	10	10	10		"
118	9^+	9^+	10	10	10	10^-	10	9^-	9	10	10^-	6-8/F		"
154	9^+	9^+	10	10	10	10^-	10	8^+	9^-	10	9^+	6-8/F		"
System 18														
7	10^-	9^+	10	10	10	10^-	10	10	9	10	10	10	4.5	Rust stain from scribe and hole in top
35	10^-	9^+	10	10	10	10^-	10	10	9^-	10	10	10		"
63	9^+	9	10	10	10	9^+	10	9^-	8	10	10	10		"
92	9^-	8^+	10	10	10	9^+	10	8	8	10	10	9^+		"
118	8^+	8	10	10	10	9^+	10	8	8	10	9^+	2-6/M		"
154	8^-	7^+	10	10	10	8^+	10	7	7	8/M	9^+	2-6/M		"

(continued)

Table 3. Continued

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting Type I	Rusting Type II	Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	
System 19														
7	10	10^-	10	10	10	10^-	10	10	10^-	10	10	10	5.3	Rust stains from scribe and hole in top
35	10	10^-	10	10	10	10^-	10	10	10^-	10	10	10		"
63	10^-	10^-	10	10	10	10^-	10	10	10^-	10	10	10		"
92	10^-	9^+	10	10	10	10^-	10	10^-	10^-	10	10	10^-		"
118	9^+	9^+	10	10	10	10^-	10	9	9^+	10	10^-	9/M		"
154	9^+	9^+	10	10	10	9^+	10	9	9^+	10	9^+	4/H		"
System 21														
7	10^-	9^+	10	10	10	10^-	10	10	9	10	10	10	5.8	Rust stains from scribe and hole in top
35	10^-	9^+	10	10	10	10^-	10	10	9	10	10	10		"
63	9^+	9^+	10	10	10	10^-	10	10	9	10	10	10		"
92	9^+	9^+	10	10	10	10^-	10	9	9^-	10	10^-	10^-		"
118	9^+	9^+	10	10	10	9^+	10	9	9^-	10	10^-	10^-		"
154	9	9^-	10	10	10	9^+	10	9^-	8	10	10^-	6/F		"
System 34														
7	10	9^+	10	10	10	10	10	10	10	10	10	10	4.9	Rust stains from scribe and hole in top
35	10^-	9^+	10	10	10	10	10	10	9^-	10	9^+	10		"
63	10^-	9^+	10	10	10	10	10	9	8^+	10	9^+	10		"
92	10^-	9^+	10	10	10	10	10	9^-	8^+	10	9^+	9		"
118	9^+	9^+	10	10	10	10^-	10	8	8	10	9^+	2-4/F		"
154	9^+	9^+	10	10	10	9	10	8	8	10	9^-	2-4/F		"

(continued)

Table 3. Continued

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discolor-ation	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting		Tubercu-lation	Rusting Scribe	Blistering	Under-cutting	Blistering Scribe	Dry Film Thickness (mils)	
						Type I	Type II							
System 35														
7	10	10	10	10	10	10	10	10	10	10	10	10	5.3	
35	10^-	10^-	10	10	10	10^-	10	10	10	2-4/H	10	10		Rust stain from scribe and hole in top
63	10^-	10^-	10	10	10	10^-	10	10	10	2-8/H	10	10		"
92	10^-	10^-	10	10	10	10^-	10	10	10	2-8/H	10	10		"
118	9^+	10^-	10	10	10	9^+	10	10	10	2-8/H	10	10		"
154	9	10^-	10	10	10	9	10	10^-	10^-	2-8/H	10	2-6/F		"
System 36														
7	10	9^+	10	10	10	10	10	10	9	10	10	10	4.4	Rust stains from scribe and hole in top
35	10	9^+	10	10	10	10	10	10	9^+	10	10	10		"
63	9^+	9^+	10	10	10	10	10	9	9	9	9^+	9		"
92	9^+	9^+	10	10	10	10^-	10	9^-	8^+	10	9^+	8		"
118	9^+	9^+	10	10	10	10	10	8	8^+	10	9	2-4/M		"
154	9^+	9^+	10	10	10	10	10	8^-	8	10	8	2-4/H		"
System 38														
7	10	10	10	10	10	10	10	10	10	10	10	10	6.1	
35	10^-	10^-	10	10	10	10^-	10	10	10^-	2-4/H	10	10		Rust stains from scribe and hole in top
63	10^-	10^-	10	10	10	10^-	10	10	10^-	2-6/H	10	10		"
92	10^-	10^-	10	10	10	10^-	10	10	10^-	2-6/H	10	10		"
118	8^+	9^+	10	10	10	9^+	10	10	10^-	2-6/H	10	10		"
154	8	9^+	10	10	10	9	10	10^-	9^+	2-6/H	10	10		"

(continued)

Table 3. Continued

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting Type I	Rusting Type II	Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	
System 40														
7	10	10^-	10	10	10	10	10	10	10^-	10	10	10	5.8	
35	10	10^-	10	10	10	10	10	10	9^+	10	9^+	10		Rust stains from scribe and hole in top
63	10^-	9^+	10	10	10	10	10	10	9^+	10	9^+	10		"
92	9^+	9^+	10	10	10	10^-	10	10	9	10	8	4-6/F		"
118	9^+	9^+	10	10	10	10^-	10	10	8	10	9	4-6/F		"
154	9^+	9^+	10	10	10	9^+	10	10	8	10	9	4-6/F		"
System 41														
7	10	9^+	10	10	10	10	10	10	9	10	10	10	5.3	Rust stains from scribe and hole in top
35	10^-	9^+	10	10	10	10	10	10	9	10	10	10		"
63	10^-	9^+	10	10	10	10	10	9^+	9	10	10	10		"
92	10^-	9^+	10	10	10	10^-	10	9^+	9	10	10	10^-		"
118	9^+	9^+	10	10	10	10^-	10	9	9	10	9^+	4-6/F		"
154	9^+	9	10	10	10	10^-	10	9^-	9^-	10	9^+	4-6/F		"

Table 4. Panel Ratings of Second Series of Coating Systems After 5% Salt Spray Exposure

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting		Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	
						Type I	Type II							
System 54														
19	10	10^{-}	10	10	10	10	10	10	9^{+}	10	10	10	6.1	
39	10^{-}	9	10	10	10	10	10	10	9^{-}	10	10^{-}	10		
65	10^{-}	8^{+}	10	10	10	10^{-}	10	10	8^{+}	10	10^{-}	9^{+}		Pinholes in topcoat
92	9^{+}	8^{+}	10	10	10	9^{+}	10	9^{-}	8	10	9	9^{+}		Yellow liquid from pinholes
123	9^{+}	8^{+}	10	10	10	9^{+}	10	8^{+}	8^{-}	10	8^{+}	8^{+}		
System 55														
14	10	10^{-}	10	10	10	10	10	10	9	10	10	10	5.7	
40	10^{-}	9^{+}	10	10	10	10^{-}	10	10^{-}	9^{-}	10	10^{-}	10		
67	10^{-}	9^{+}	10	10	10	10^{-}	10	10^{-}	9^{-}	10	10^{-}	10		
98	10^{-}	9^{+}	10	10	10	10^{-}	10	9^{+}	9^{-}	F/4	10^{-}	10		
System 57														
14	10	10	10	10	10	10	10	10	10^{-}	10	10	10	2.0	
40	10^{-}	9^{+}	10	10	10	9	10	10	10^{-}	10	10	10		
67	9^{-}	9^{+}*	10	10	10	9^{-}	10	10	10^{-}	10	10	10		(*One side only)
98	8	9^{-}*	10	10	10	8	10	10	10^{-}	10	10	10		(*One side only)
System 58														
19	10	10^{-}	10	10	10	10	10	10	10^{-}	10	10	10	5.6	
39	10	10^{-}	10	10	10	10	10	10	10^{-}	10	10	10		
65	9^{+}	9^{+}	10	10	10	9^{+}	10	10^{-}	9^{+}	10	10^{-}	F/6-8*		(*Front side only)
92	9	9^{-}	10	10	10	9	10	9^{+}	9^{+}	10	9^{+}	F/6-8*		(*Front side only)
123	9	9^{-}	10	10	10	9^{-}	10	9^{+}	9^{-}	10	9^{+}	F/6-8*		(*Front side only)

(continued)

Table 4. Continued

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting		Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	
						Type I	Type II							
System 59														
19	10	10^-	10	10	10	10	10	10	10^-	10	10	10	7.5	
39	10	10^-	10	10	10	10	10	10	9^+	10	10	10		
65	9	9^-	10	10	10	10^-	10	10^-	9	10	9^+	M/2-4		
92	9	8^+	10	10	10	10^-	9	9^-	8	10	9^-	M/2-4		
123	9	8^+	10	10	10	10^-	9	9^-	8	10	8^-	M/2-4*		(*Scribe side only)
System 60														
19	10	10^-	10	10	10	10^-	10	10^-	9^+	10	10^-	10^-	6.5	
39	10	9^+	10	10	10	10^-	10	9^+	9	10	9^+	9^+		
65	9^+	9^+	10	10	10	10^-	10	8	8^+	10	9	M/2-4*		(*Scribe side only)
92	8	9^+	10	10	10	10^-	10	8^-	8	10	9^-	M/2-4*		(*Scribe side only)
123	8	9^+	10	10	10	10^-	10	8^-	7^+	10	8	M/2-4*		(*Scribe side only)
System 66														
19	10	10^-	10	10	10	10	10	10	10^-	10	10	10	9.0	
39	10	10^-	10	10	10	10*	10	10	9^+	10	10	10		(*Scribe only)
65	10^-	9	10	10	10	10	10^-	10	9^-	10	9	M/2-4*		(*Scribe side only)
92	9	9	10	10	10	10^-	10^-	9^+	8^+	10	8	M/2-4*		(*Scribe side only)
123	9	9^-	10	10	10	10^-	10^-	9	8	10	7	M/2-4*		(*Scribe side only)
System 67														
14	10	10	10	10	10	10	10	10	10^-	10	10	10	4.7	
40	10^-	10^-	10	10	10	10	10	10	10^-	10	10	10		
67	10^-	10^-	10	10	10	10	10	10	10^-	F/8	10	F/8*		(*One side only)
98	10^-	10^-	10	10	10	10^-	10	10	10^-	F/8	10	F/8*		(*One side only)

(continued)

Table 4. Continued

Exposure (days)	Rating for Following Properties –													Remarks
	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting		Tuberculation	Rusting Scribe	Blistering	Undercutting	Blistering Scribe	Dry Film Thickness (mils)	
						Type I	Type II							
System 68														
19	10	10^-	10	10	10	10	10	10	10^-	10^-	10	10	3.9	
39	10	10^-	10	10	10	10	10	10	9^+	10	10	10		
65	9^+	9^+	10	10	10	9^+	10	9^+	9	10	9^+	10		
92	9^-	9^+	10	10	10	9	10	9^-	8^+	M/8	9^-	F/8*		(*One side only)
123	8^+	9^+	10	10	10	9	10	8^+	8^+	M/6-8	9^-	F/8*		(*One side only)
System 69														
19	10^-	10^-	10	10	10	10^-	10	10	10^-	10	10	10	6.3	Few large blisters
39	9^+	9^+	10	10	10	9^+	10	10	10^-	F/2	10	10		Delamination topcoat from primer
65	9^-	9^-	10	10	10	9^-	9	10	10^-	M/2-4	10	10		"
92	8^-	8	10	10	10	8	9	10	10^-	M/2-4	10	10		"
123	8^-	8	10	10	10	8	8	10	10^-	M/2-4	10	10		"
System 70														
19	10^-	10^-	10	10	10	10^-	10	10	10^-	10^-	10	10	6.3	
39	10^-	10^-	10	10	10	10^-	10	10	10^-	10^-	10^-	10		
65	9	9	10	10	10	9	10	10^-	10^-	10^-	10^-	10		
98	–	–	–	–	–	–	–	–	–	–	–	–		Failed – lost topcoat primer one side

NOTE: Definitions of abbreviations: F = few, M = medium, H = heavy.

Table 5. Ratings of Coatings on Antennas After 15 Months of Exposure at PMTC

Coating System	General Protection	Discoloration	Chalking	Alligatoring, Checking, Cracking	Scaling, Flaking, Peeling	Rusting		Blistering	Total Thickness (mils)	Remarks
						Type I (Without Blistering)	Type II (With Blistering)			
Antenna I, Bldg 854, Inland										
54	Failed								18	Mold: Black, Blue, Green
55	10	10	10	10	10	10	10	10	15	
56	Failed								10	Localized blistering
57	10^-	10^-	8	10	10	10^-	9^+	10	9	
58	9	10^-	6	10	10	9	9	10	4	
59	9^+	9^-	4	10	10	9^+	9	10	7	
60	10^-	10	10	10^-	10	10^-	10^-	10	10	
61	10^-	10	2	10	10	10^-	10^-	10	12	
62	9	9	10	6^-	10	9	9^+	10	14	7.0% cracking
63	10^-	10	10	10	10	10^-	10^-	10	7	
64	10	10^-	2	10^-	10	10	9^+	10	18	
65	10	10	4	10^-	10	10	10	10	12	
Antenna II, Bldg 855										
54	8	6	6	10	10	8	9	9^+	12	
55	10	10^-	6	9	10	10	10^-	10	17	
56	Failed								10	
57	10	10	10	10	10	10	10	10	9	
58	8^-	9	10	10	9^+	8^-	9^-	8^+	$>20^+$	
59	9^-	5	4	10^-	10	9^-	9^-	9^+	7	
60	9	10	6	8	10	9	9^-	9	9	
61	10	10	4	10	10	10	10^-	10	15	
62	10	10	8^+	10	10	10	10	10	12	
63	10^-	9^+	10	10	10	10^-	10^-	10	6	Mold: Black, Green
64	10	10	2	10^-	10	10	10	10	$>20^+$	Localized blistering
65	10^-	10	4	10	10	10^-	10	10	18	

Table 6. Surface Preparation Standards for Abrasively Blasted Steel

Surface Finish	NACE Standard (Ref 10)	SSPC Standard (Ref 7)	SSPC/SIS Visual Standard (Ref 7)
White Metal Blast	1	5	CSa3
Near-White Blast	2	10	CSa2-1/2
Commercial Blast	3	6	CSa2
Brush-Off Blast	4	7	CSa1

Table 7. Coatings Commonly Used on Steel Tower Structures

Generic Type	Minimum Surface Preparation Recommended	Ease of Repair and Topcoating	Important Properties
Alkyd	Commercial, but tool or brush-off may be OK	easy	Wets surface well; weathers well; protection good in most environments.
Vinyl	Commercial or near white	easy	Protection good in all environments.
Chlorinated Rubber	Commercial or near white	easy	Fast curing; protection good in all environments.
Epoxy-Polyamide	Commercial	difficult*	Excellent protection; chalks freely in sunlight.
Urethane	Commercial or near white	difficult*	Excellent protection; aliphatic urethanes have excellent exterior weathering.
Inorganic Zinc	Near white or white	difficult*	Excellent abrasion resistance; used as preconstruction primers.
Organic Zinc	Commercial or near white	varies	More easily topcoated than inorganic zincs.

*Special precautions must be taken in topcoating chemically curing coatings.

Table 8. Typical 1978 West Coast Surface Preparation and Primer Costs[a]

Item	Cost ($/sq ft)	
	Field	Shop
SSPC Surface Preparation		
Commercial Blast (SSPC-SP 6)	0.50	0.25
Near White (SSPC-SP 10)	0.65	0.30
White Metal (SSPC-SP 5)	0.90	0.40
Primer (Generic Type)[b]		
Alkyd, Vinyl, or Chlorinated Rubber	0.10	0.06
Epoxy	0.15	0.11
Zinc Rich	0.20	0.16

[a]From Reference 14.

[b]Does not include cost of coating material.

Table 9. Typical 1978 West Coast Costs for Coating New Antenna Towers[a]

Item	Cost of Coating System ($/sq ft)				
	Alkyd	Vinyl	Chlorinated Rubber	Epoxy	Zinc Rich[b]
Shop blasting[c]	0.25	0.30	0.25	0.25	0.30
Shop priming	0.06	0.06	0.06	0.11	0.16
Primer material	0.025	0.056	0.054	0.041	0.087
Field application of intermediate coat[d]	0.20	0.20	0.20	0.25	0.25
Intermediate coating material	0.022	0.136	0.092	0.079	0.041
Field application of finish coat	0.10	0.10	0.10	0.15	0.15
Finish coating material	0.022	0.053	0.038	0.037	0.059
Total	0.679	0.905	0.794	0.917	1.047

[a]From Reference 14.

[b]Self-cure inorganic zinc primer, high-build epoxy intermediate coat, and aliphatic urethane topcoat.

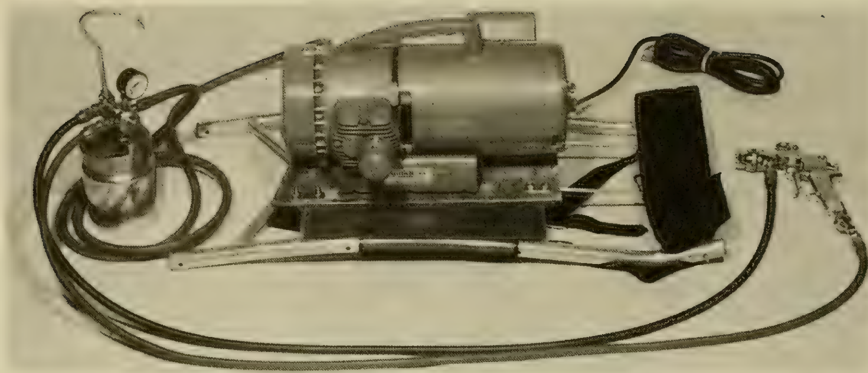
[c]Commercial blast for alkyd, chlorinated rubber, and epoxy; near white blast for vinyl and zinc rich.

[d]Includes $0.10 for field touchup of damaged areas (10%).

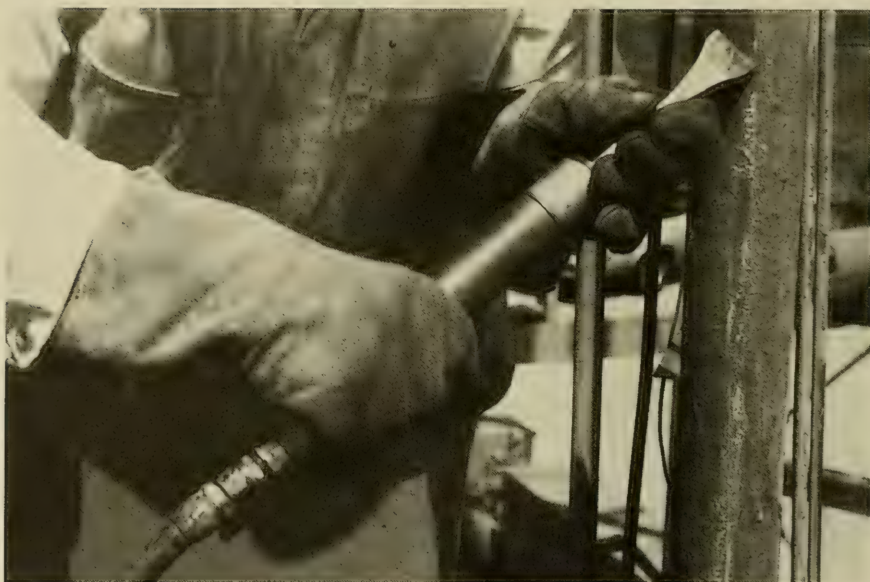
Table 10. Relative Costs and Expected Service Lives of Coating Systems in Different Industrial Environments[a]

Coating System	Relative Cost	Expected Years of Life in Industrial Environment		
		Mild	Moderate	Severe
Alkyd	1.00	7	5	3
Vinyl	1.40	10	9	8
Chlorinated Rubber	1.16	10	9	8
Epoxy	1.42	10	8	6
Zinc Rich	1.54	12	10	7

[a]From Reference 14.

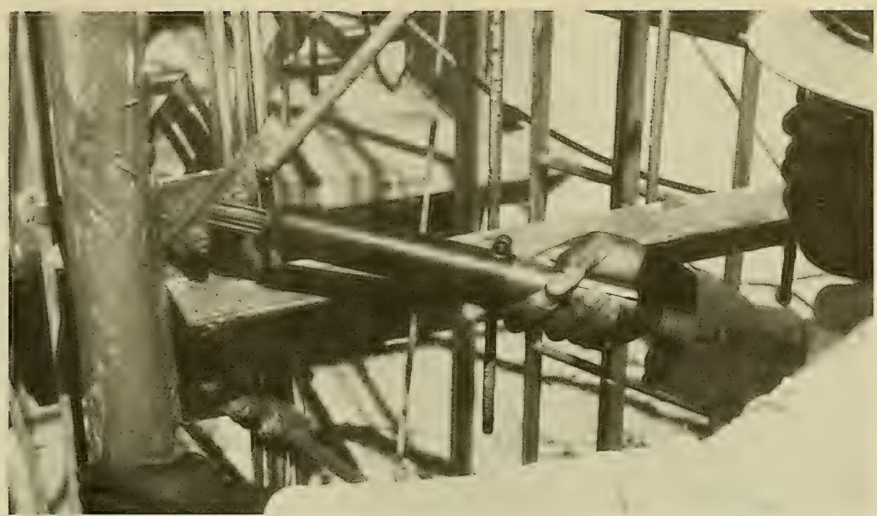


(a) Paint spraying equipment attached.

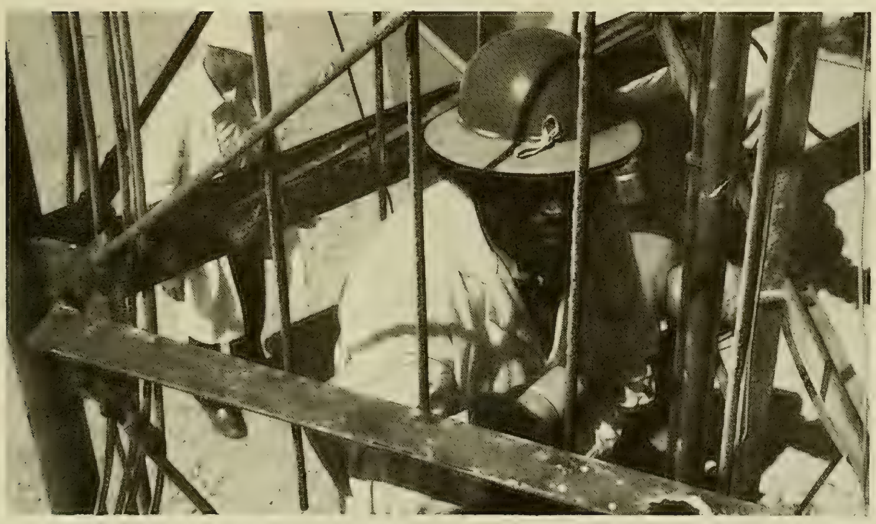


(b) Chiseling.

Figure 1. Portable backpack unit.

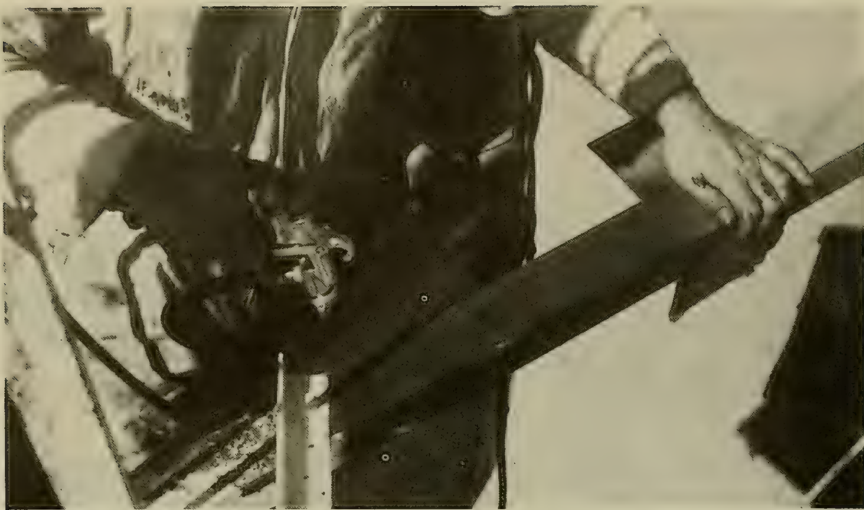


(c) Needling.



(d) Sanding.

Figure 1. Continued



(e) Spraying.

Figure 1. Continued

Figure 2. Antenna field.

Figure 3. Communication facility.

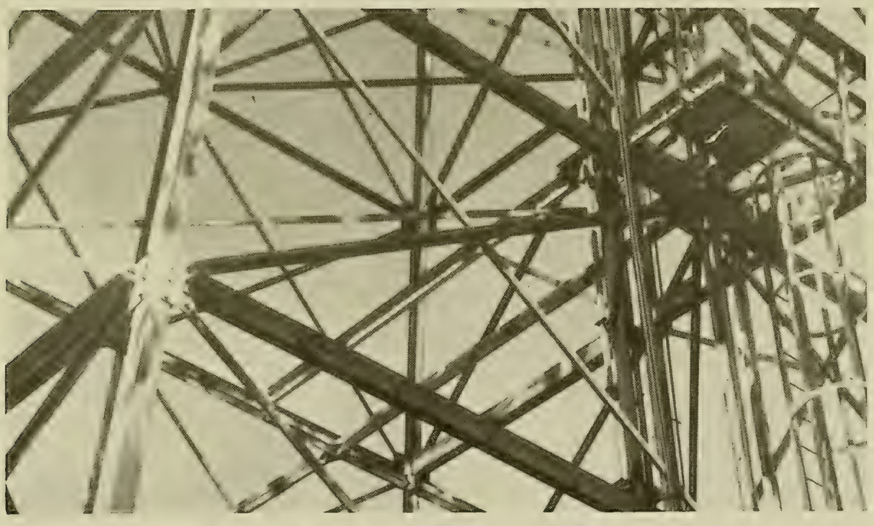


Figure 4. Rusty steel tower.

Figure 5. Paint peeling from galvanized steel.

Figure 6. Circularly disposed (Wullenweber) antenna array. (Neg #12411-70)

Tower stairs and railing.

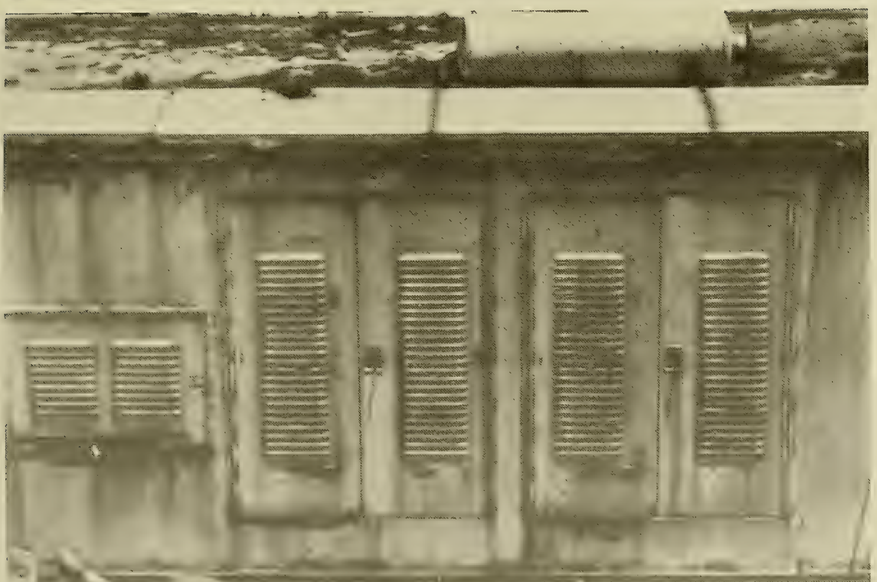


Figure 8. Trailer with support equipment.

Figure 9. Crossed guy lines.

Figure 10. Crossed guy lines with sleeves.

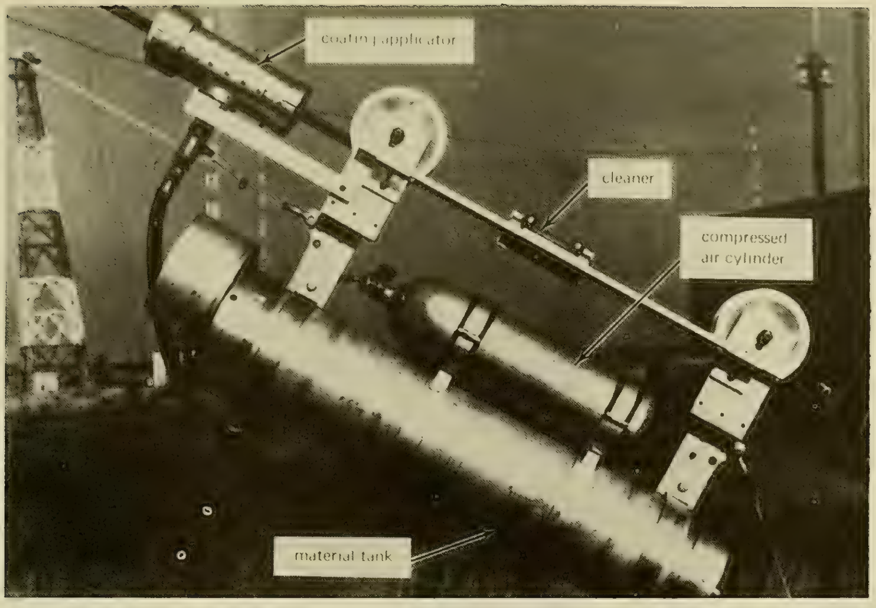


Figure 11. Equipment for remote coating of guy lines.

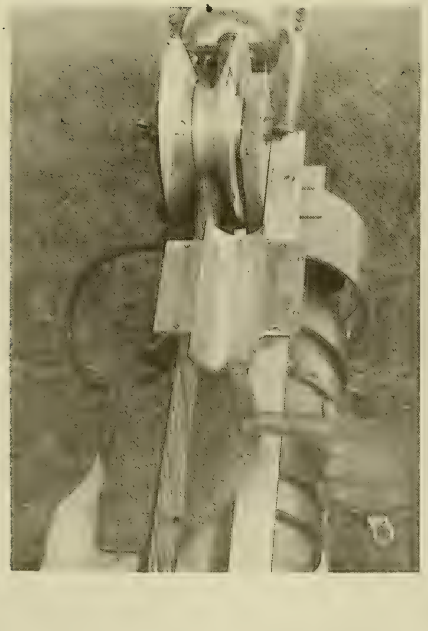


Figure 12. Cleaning equipment with nylon brush shown.

Figure 13. Equipment ascending guy line.

Figure 14. Glass-reinforced plastic guy line with dampener.

Appendix A

TYPE AND SOURCES OF COATING SYSTEMS USED ON SECOND SERIES SALT-SPRAY EXPOSURE

System No.	Primer Type	Coating System		System Components	Use[a]	Total Thickness (mil)
		Source of Primer or Topcoat	Specification No. or Trade Name			
66	epoxy polyamide	Proline Paint Mfg. Co. 2646 Main St. San Diego, CA 92113	MIL-P-24441-150	epoxy-polyamide	primer	9.0
		Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	3-1W-7	epoxy-urethane	topcoat	8.9
67	zinc-rich chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	6 DLP 140	zinc-rich chlorinated rubber	primer	5.0
		Proline Paint Mfg. Co. 2646 Main St. San Diego, CA 92113	MIL-P-24441-151	epoxy-polyamide	topcoat	4.3
68	zinc-rich chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	6 DLP 63	zinc-rich chlorinated rubber	primer	3.8
			MIL-C-81773	polyurethane	topcoat	4.0

(continued)

System No.	Primer Type	Coating System		System Components	Use[a]	Total Thickness (mil)
		Source of Primer or Topcoat	Specification No. or Trade Name			
69	zinc-rich chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91773	6 DLP 63	zinc-rich chlorinated rubber	primer	6.3
		Mobil Chemical Co. P.O. Box 250 Edison, NJ 08817	Mobil Val Chem	chlorinated rubber	topcoat	6.2
70	zinc-rich chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	6 DLP 63	zinc-rich chlorinated rubber	primer	6.3
			3-1G-1	epoxy-urethane	topcoat	6.3

[a]The pigment in all the topcoats for this test was white.

Appendix B

FORMULAS OF EXPERIMENTAL PAINTS USED ON VORTEX TOWERS

Material	Pounds	Gallons
Field-Applied Antenna Touchup Coating Primer: 3-1G-1		
2 Nitropropane	148.86	18.00
Toluol	124.60	17.20
Epoxy Resin	85.00	8.90
Grinding Aid (Prod. 963)	2.12	0.28
Basic Lead Silico Chromate	590.00	17.30
Black Oxide	55.00	1.30
Talc	92.00	4.00
Mica	93.00	4.00
Grinding Aid (MPA-60)	5.00	0.74
Ethyl Acetate	135.36	18.00
Butyl Titanate	0.60	0.07
Vegetable Oil	106.00	13.20
Field-Applied Antenna Touchup Coating Finish: 3-1W-7		
Toluol	118.17	16.32
Epoxy Resin	76.93	7.96
Grinding Aid (Prod. 963)	5.43	0.72
Vegetable Oil	95.04	11.22
Moly White	267.00	10.86
Barium Metaborate	267.00	9.68
Talc	83.72	3.71
Mica	83.72	3.53
Grinding Aid (MPA-60)	5.43	0.81
Titanium Dioxide	181.02	5.52
2 Nitropropane	135.77	16.38
Ethyl Acetate	122.19	16.29
Butyl Titanate	0.58	0.06

(continued)

Material	Pounds	Gallons
Chlorinated Rubber Based Zinc-Rich Primer: 6 DLP 63		
Varnish and Paintmaker Naphtha	104.04	17.00
Xylol	6.07	0.84
Bentone 38	15.00	1.00
Zinc Oxide	150.00	3.18
Methyl Ethyl Ketone	104.03	15.48
Toluol	72.30	10.00
Cellulose Acetate	97.20	12.00
Chlorinated Rubber	65.12	4.76
Dibasic Lead Phosphate	2.08	0.26
Chlorinated Olefin	52.08	4.49
Zinc Dust	1,978.00	33.88
Butyl Titanate	1.06	0.12
Chlorinated Rubber Zinc-Rich Primer: 6 DLP 140		
Varnish and Paintmaker Naphtha	78.22	12.79
Xylol	303.35	41.96
Chlorinated Rubber	64.32	4.70
Bentone 38	11.56	0.77
Zinc Oxide	98.77	2.09
Zinc Dust #22	2,101.78	36.00
Chlorinated Olefin	51.44	4.43
Dibasic Lead Phosphate	2.05	0.26
Butyl Titanate	>0.50	
Corrosion-Free Wet Wall Red #11105: 3-1R-13		
Epoxy Resin	74.39	7.70
Vegetable Oil	91.91	10.85
Grinding Aid (Prod. 963)	5.25	0.70
Moly White	258.20	10.50
Barium Metaborate	258.20	9.36
Talc	80.96	3.59
Mica	80.96	3.42
Grinding Aid (MPA-60)	5.25	0.78
Toluidine Red	106.37	8.73
2 Nitropropane	131.30	15.84
Toluol	114.28	15.78
Ethyl Acetate	118.16	15.75
Butyl Titanate	>0.50	

Appendix C

COATING SYSTEMS USED ON VORTEX TOWERS

System No.	Primer Type	Coating System		System Components	Use	Total Thickness (mil)
		Sources of Primer	Specification No. or Trade Names			
54	alkyd	Enjay Chemical Co. 8230 Stedman St. Houston, TX 77029	Enjay #6262	alkyd zinc chromate	primer	18
			TT-E-489D Amendment 1 Class A	alkyd enamel	finish	12
55	chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	6 DLP 140	chlorinated rubber zinc rich	primer	15
			3-1R-13	epoxy-urethane	finish	17
56	chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	6 DLP 140	chlorinated rubber zinc rich	primer	10
			Mobil Val Chem	chlorinated rubber	finish	10
57	chlorinated rubber	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	6 DLP 140	chlorinated rubber zinc rich	primer	9
			MIL-C-81773	polyurethane	finish	9
58	epoxy-urethane	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	3-1G-1	epoxy-urethane	primer	4
			MIL-C-81773	polyurethane	finish	28
59	epoxy-urethane	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	3-1G-1	epoxy-urethane	primer	10
			MIL-P-24441-152	epoxy-polyamide	finish	9

(continued)

System No.	Primer Type	Coating System		System Components	Use	Total Thickness (mil)
		Sources of Primer	Specification No. or Trade Names			
60	epoxy-urethane	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	3-1G-1	epoxy-urethane	primer	10
			3-1R-13	epoxy-urethane	finish	9
61	epoxy	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	4-10-4	epoxy	primer	12
			MIL-P-24441-156	epoxy-polyamide	finish	15
62	epoxy	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	4-10-4	epoxy	primer	14
			3-1R-13	epoxy-urethane	finish	12
63	epoxy	Advanced Coatings and Chemicals 2213 North Tyler Ave. South El Monte, CA 91733	4-10-4	epoxy	primer	7
			MIL-C-81773	polyurethane	topcoat	6
64	epoxy-polyamide	Proline Paint Mfg. Co. 2646 Main St. San Diego, CA 92113	MIL-P-24441-150	epoxy-polyamide	primer	18
			MIL-P-24441-156	epoxy-polyamide	topcoat	20+
65	epoxy-polyamide	Carboline 350 Hanley Industrial Ct St. Louis, MO 63144	Carboline 188	epoxy-polyamide	primer	12
			MIL-P-24441-156	epoxy-polyamide	topcoat	18

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